increased thoracic aortic size. Our observations had a main limitation: because the present study was based on cross-sectional data, it is difficult to prove that OSA accelerates aortic expansion.

The present study indicates that OSA could contribute to greater thoracic aortic size.

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Letters to the Editor

Limitations of Angiographic Predictors of Bypass Graft Patency

I compliment the work of Glineur et al. (1) on advancing our appreciation of the physiologic predictors of 6-month patency rates of bypass grafts to the right coronary artery. The patency of the gastroepiploic artery (GEA) had a significant association with minimal luminal diameter (MLD) and percent diameter stenosis, angiographic features that did not affect saphenous vein graft patency rates as much. A larger MLD (>1.4 mm) and the percent diameter stenosis (<55% narrowing) predicted GEA graft closure. The accompanying editorial by Sabik and Blackstone (2) expertly reviewed the evidence for competitive flow and coronary artery bypass graft patency, explaining some of the factors in play for the outcomes reported by Glineur et al. (1).

Although competitive flow between native and grafted coronary vessels has been known to surgeons for many years as a cause of graft failure (3–5), the prediction of graft patency on the basis of the physiology of competitive flow should not be judged by angiography alone. The numerous studies on intracoronary pressure and intravascular ultrasound imaging reinforce the failure of the angiogram to provide important physiologic and true anatomic information, especially for intermediately severe stenoses (6,7). Using angiography as a surrogate for physiologic activity is often erroneous and, at this time, is an imprecise technique when addressing physiologic mechanisms as described by Sabik et al. (5) and others (3,4). The competing flow potential of the native artery with vein graft flow can be directly measured by coronary pressure or Doppler flow in patients in the cardiac catheterization laboratory (6,8).

The measurement of hyperemic translesional pressure ratio, called fractional flow reserve (FFR) (8,9), has been applied to study the fate of coronary bypass grafts with striking results. Confirming the relevance of the physiologic stenosis severity and graft patency, Botman et al. (10) report the 1-year follow-up of 164 patients undergoing coronary bypass grafts. All vessels grafted had FFR measured beforehand with the pressure sensor angioplasty guidewire in the catheterization laboratory. At 1 year, 9% of grafts on functionally significant lesions were occluded, whereas 21% of grafts on functionally nonsignificant lesions were occluded. A significant graft occlusion rate was observed for grafted vessels with near normal physiology (FFR >0.80, normal = 1.0). The angiographic percent diameter narrowings displayed a similar but less precise correlation with graft failure. The findings from Botman et al. (10) again emphasize what is generally appreciated but unmeasured: that is, the physiologic impact of intermediately severe stenosis remains unknown by angiography.

Whereas the angiographic descriptor of MLD provided by Glineur et al. (1) is an advance over measurements of stenosis diameter (even if using a quantitative angiographic imaging system), the precise pressure across stenosis can be obtained often without difficulty by most interventional cardiologists. Certainly, severe narrowings and total occlusions do not need such direct measurements, but the physiologic assessment of intermediate lesions can assist selection of the appropriate bypass graft should the surgeon have an interest in this approach (11).

Sabik and Blackstone (2) note that using only maximal coronary artery stenosis would not adjust for coronary artery size, whereas MLD does this to a larger extent. However, neither MLD of the reference lumen diameter nor percent lumen diameter narrowing truly reflects competitive flow physiology. Although I recognize this might not be possible in many clinical settings, I believe

angiographic parameters cannot and should not be used as a surrogate for coronary flow.

Finally, recent data by Sant'Anna et al. (12) challenge our assumptions regarding whether angiographic 3-vessel disease is truly physiological 3-vessel disease. Of the 250 patients undergoing angiography, when the 27% of patients with angiographic 3-vessel disease had FFR measured in all 3 of these vessels, only 9% were found to have physiologically significant 3-vessel coronary disease. Had bypass grafting been performed, a considerable incidence of graft failure would be expected at follow-up. Fortunately, in this setting graft failure is often clinically silent with the consequences of graft closure across nonsignificant lesions reverting to the native vessel, which remains patent and functional (unless the lesion progresses).

Whereas the debate about the use of the GEA graft continues, a critical question before the surgery for those vessels with intermediately severe stenoses should be answered by direct physiologic measurements: is a graft on this particular vessel going to be of any use if the physiology is nearly normal (13)?

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Please note: Dr. Kern is a speaker for Radi Medical and Volcano Therapeutics, 2 companies that manufacture the pressure guidewire used in the physiologic assessment of coronary artery disease.

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Reply

Dr. Kern wisely raised several points that were not discussed in our article (1). We are convinced of the interest of fractional flow reserve (FFR) as a tool to asses the physiological relevance of coronary stenoses, and we recently used this tool to compare the resistance to blood flow of several coronary graft configurations (2,3). Unfortunately, if all patients referred to bypass surgery underwent a pre-operative angiographic evaluation and if most of those angiographic documents could be analyzed quantitatively, very few patients would be referred to surgery with a full mapping of FFR on the different coronary segments.

In daily clinical practice, the use of FFR remains generally restricted to the evaluation of stenoses of intermediate severity and mainly in patients with <3-vessel disease who are planned to be treated by interventional cardiology. For patients referred to surgery with a 2- or 3-vessel disease, the decision to measure FFR for an intermediate stenosis associated with angiographically severe narrowing on other coronary segments is much less frequent, because the surgical indication is already present, on the basis of the critical lesions. In these cases, most cardiac surgeons choose to graft the intermediate lesion as well, even if this bypass is at risk of competitive flow. This attitude, although somewhat empirical, is based on the low risk expected from the possible occlusion of such nonfunctional grafts, on the hope that these grafts will remain patent long enough to provide some help in the case of progression of the intermediate lesion, and on the fear of a redo intervention, if lesion severity is underestimated. It still remains uncertain whether this is preferable to a more conservative attitude consisting of graft implantation only on severely narrowed coronary segments.

Several observations have illustrated the capacity of the internal thoracic artery (4) or right gastroepiploic artery (RGEA) (5) to recover function in the long term after having been found not functional (string sign) at early follow-up. This capacity seems related to endothelial protection mechanisms that are probably less prominent or totally absent in saphenous vein graft. Considering the natural progression of the disease on native vessels, this property could act in favor of RGEA in the longer term. The ongoing angiographic re-evaluation of the grafts at 3 years postoperatively could thus provide information susceptible to clarifying the meaning of these early findings, particularly in RGEA grafts with a balanced flow.

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